TOWARDS FLEXIBLE ELASTODYNAMIC WAVE SIMULATION IN THREE DIMENSIONS

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Ultrasonic nondestructive testing (NDT) is often used to evaluate the properties of materials without causing damage. Very short pulse waves are launched into the material to detect and characterize internal flaws. A standard ultrasonic NDT technique searches for reflections at cracks and delaminations. Nonlinear elastodynamic wave spectroscopy (NEWS) is a rather new technique where the higher-harmonic content of the propagating ultrasonic wave is measured [5]. The higher harmonics originate at nonlinearities, which gives an indication of incipient damage. The nonlinearity of slightly damaged material is typically represented by a hysteretic stress-strain characteristic.

Numerical modeling of the radiation, propagation and scattering of elastodynamic waves is helpful to reduce the number of (sometimes expensive) physical NDT experiments. Fine-tuning the numerical model by optimizing for example the number and location of sensors, allows practitioners to increase the efficiency of their measurements.

For our applications, the basic equations for elastodynamic wave propagation are commonly resolved by a volume-discretization scheme in order to allow inhomogeneous, anisotropic and nonlinear materials. Several numerical schemes such as the finite difference time domain methods (FDTD) [2], finite element methods (FE) [4] or elastodynamic finite integration technique (EFIT) [3] exist. Often, these schemes are very similar to their counterparts in electromagnetics.

In [3], EFIT is formulated for anisotropic inhomogeneous media in 3D. However, technically relevant 3D elastodynamic simulations remain challenging, especially in the presence of complicated geometries and hysteretic material properties. We have started an implementation based on Bihn's Finite Integration (FI) approach [1]. We aim at the combination of Bihn's framework with the hysteretic models developed at the institute.

Keeping in mind parallelization as a backup strategy, our hope is that more than 10 years after the publication of Bihn's PhD thesis, computational power has increased enough to make three-dimensional FI-simulations of elastodynamic wave propagation possible for large and nonlinear models.

References:

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